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SOCIAL BEHAVIOR, HABITAT, AND FOOD OF THE BEECHEY JAY

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As part of a long-term comparative investigation of the ecology and evolution of social behavior in the black-and-blue jays (genus *Cyanocorax*, subgenus *Cissilopha*) of Middle America we began a field study of the Beechey or Purplish-backed Jay (*C. beecheii*) in 1974. Other members of the group, particularly the Bushy-crested Jay (*C. melanocyanea*), the northern form of the San Blas Jay (*C. sanblasiana nelsoni*), and the Yucatan Jay (*C. yucatanica*), were already known to be highly social and to exhibit cooperative breeding (Hardy 1976, Raitt and Hardy 1976). Scattered literature reports and some casual field observations had indicated that the Beechey Jay was much less social than its close relatives, and it seemed, therefore, of importance to examine its social system, the adaptive basis of the system, and its relation to population structure and dynamics.

The project is a continuing one; we expect to obtain additional results based on birds already marked, but the basic outlines of the nature of the social system are already evident. In this paper we describe and analyze some aspects of that system, reserving for a later report details of the population ecology.

STUDY AREA AND METHODS

Field studies on the jays centered on the essential matters of locating nests and observing activity at them and of capturing and marking the birds. The jays are shy, relatively quiet, and difficult to observe and follow in the dense forest. We attempted to bait them to live-traps (both walk-in and bal chatri types), but with little success. We captured 28 fully grown individuals, most in mist nets placed near active nests. Most of the 33 young birds marked were captured by hand, either in or near nests. Colored plastic markers (Raitt and Hardy 1976) in distinctive combinations were applied to both legs of each captured bird. In addition, in 1975 and 1976 matching colored plastic leg bands were applied. Age determination of birds seen or captured was based on color

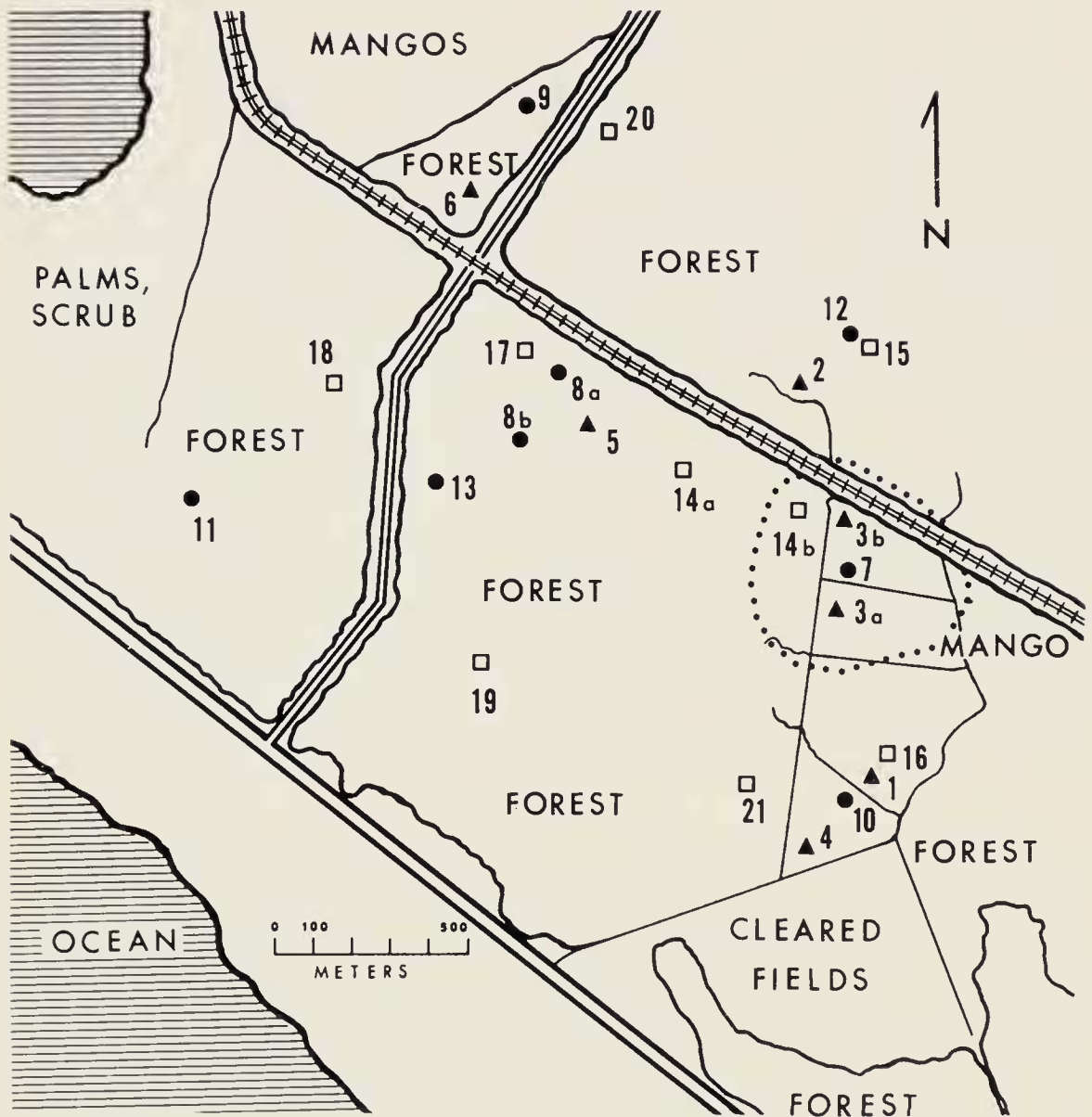


FIG. 1. Principal features of study area approximately 6 km north of Mazatlán. Closed dotted line indicates approximate boundary of observed home range of group B, 1974–75. Numbered symbols indicate locations of nests in 1974 (triangles), 1975 (circles), and 1976 (open squares); lower case letters indicate sequential nestings of the same group in a given year.

of bill and eye, following Hardy's (1973) criteria for recognition of yearlings, 2-year-olds, and adults (birds 3 years or older) (see frontispiece).

For indications of diet, 12 individuals in 1974 and 2 in 1975 were shot in places well away from the main study area. Stomach contents were preserved for analysis in the lab.

Vegetation of the study area was analyzed by means of a system of circular plots, each 100 m², using methods modified from those described by James and Shugart (1970) and like those used on our Yucatan Jay study area in Campeche (Raitt and Hardy 1976). The 15 plots were placed in a random-stratified manner, 12 in the main portion of the area, and 3 in the lesser portion northeast of the railroad tracks (see Fig. 1). Within each we measured DBH of each woody stem 2.0 cm or greater in DBH,

counted smaller woody stems (designated as shrubs or vines) in 2 randomly located 81° sectors (combined area per plot = 45 m²), and made cover measurements and notes on foliage, flowering, and fruiting.

Our study area was near Mazatlán, Sinaloa, México. This locality is the approximate center of the species' geographic range, which extends along the coastal plain from southern Sonora (vicinity of Alamos) to northern Nayarit (near Sauta, north of San Blas) (Miller et al. 1957). Dates and degree of field effort are as follows: 4 June–14 July 1974, 6 workers, 177 worker-days; 28 December 1974–3 January 1975, 3 workers, 21 worker-days; 7 June–25 July 1975, 7 workers, 158 worker-days; 29 November–3 December 1975, 3 workers, 15 worker-days; and 24 May–25 July 1976, 9 workers, 193 worker-days.

The study area consists of a tract of deciduous forest that seems to represent optimum habitat, approximately 6 km north of Mazatlán (Fig. 1). The topography is relatively flat, with shallow, dry gullies, except for 2 clusters of small hills that rise perhaps 50–100 m above the general level of the coastal plain. The wide-ranging habits of the jays and their generally sparse occurrence necessitated progressive enlargement of the study area, to over 300 ha, including virtually all of the forested area southwest of the railroad and a sizeable strip northeast of it (Fig. 1).

Data on weather at Mazatlán for 1951–1960 are presented in U.S. Dept. Commerce (1965). Winters are typically dry and mild in temperature (mean for January and February = 20°C); summers are wet and hot (mean for July–September = 28°C). The mean annual rainfall was 805 mm. This amount is not strikingly different from the mean of 1025 mm at our Yucatan Jay study area in Campeche (Raitt and Hardy 1976), but the dry season is much longer and more severe at Mazatlán. In 8 of 10 years there were 6 or 7 months per year with less than 5 mm of rainfall, whereas in Campeche under 2 months had less than 5 mm of rainfall. Beechey Jays and their associated organisms must be adapted to the unfavorable conditions imposed annually by a 6-month period virtually without precipitation.

Except for trails, roads, the railroad right-of-way, and some fields and orchards at the margins, the area is homogeneously forested. Some of the important characteristics of this forest are shown in Table 1. The high densities of woody plants and the relatively low stature of the canopy are likely reflections of cutting. Selective cutting, primarily for fence posts, appears to continue unabated. The values in Table 1 are for all species combined. The most important tree species is *Trichilia trifolia*, which accounted for 46% of the density and 33% of the basal area on our plots and occurs on 13 of the 15. Other important trees were *Zizyphus amole*, *Guazuma ulmifolia*, *Ceiba acuminata*, *Tabebuia rosea*, *Morisonia americana*, and *Caesalpinia eriostachys*. A species of *Cochlospermum* and 1 of *Ficus* were represented by conspicuous individuals in the area, but were not sampled on our plots.

On a recent large-scale vegetation map of México (Flores Mata et al. 1971) the forests of the region are classified as low deciduous forests (*selva baja caducifolia*), and our observations confirm their deciduous character. In mid-June 1974, near the end of the dry season, only a few trees bore green leaves; the only species appearing to be fully leafed were *Zizyphus amole* and the *Ficus*; although most of the *Trichilia* bore a number of leaves, none of them was bright green and most were yellow or brown. June 1976 was similar, but in June 1975, the dry season had been less severe and more leaves were green and a few more trees and a small number of shrubs were leafy. Within 2 weeks of the onset of frequent, substantial rains, on 20–21 June 1974, 5–6 July 1975, and 14–15 June 1976, the character of the vegetation had changed markedly; nearly

TABLE 1

SUMMARY OF VEGETATION CHARACTERISTICS OF THE BEECHIEY JAY STUDY AREA

	Mean	Range
Trees		
Density (no. per 100 m ²)	61	32-119
Basal area (cm ² per 100 m ²)	1291	576-2101
Height of canopy (m)	7.5	6-10
Shrub-vine density (no. per 100 m ²)	168	84-420

all of the trees and shrubs were fully leafed and heavy herbaceous growth had appeared on unshaded ground. Reflecting this change the mean canopy cover value for the sample plots changed from 51% in June 1974 to 73% in July. Flowering and fruiting were not heavy, widespread, or absent, during any of our field work, but they were most common in our winter visits to the area.

SOCIAL STRUCTURE

Groups.—The sizes and composition of the breeding groups in the study population are indicated in Table 2. The basic social unit appears to be an adult male-female pair, with or without 1 to 3 additional fully grown birds. The mean size of 20 groups was 3.4 individuals. Ages of the birds accompanying the nucleus pair differed among groups, but yearlings predominated over adults and 2-year-olds. In no case did we detect more than 1 other adult. One exception to the rule of a nucleus pair of adults was group C in the breeding season of 1974, in which the nucleus female was a 2-year-old. Group sizes seemed to increase from 1974 to 1976, but data are too few for statistical confirmation.

In the breeding season, when most of our observations were made (May–August), these groups appeared to be cohesive and stable in membership. Except for individuals actually attending nests, members remained together most of the time and, as will be described later, all members participated in the care of nestlings. In these respects the groups were similar to the generally larger ones characteristic of related species (Hardy 1976, Raitt and Hardy 1976).

Less intensive study in winter indicated that groups retained their integrity in the non-breeding months and that young-of-the-year remained with the

TABLE 2
COMPOSITION OF BREEDING SEASON GROUPS OF BEECHEY JAYS

Group: Nests:	A 1, 4, 10, 16	B 3A, B, 7, 14A, B	C 5, 8A, B, 17	D 2	E 12,15	F 6,9,20	G 13	H 11,18	I 19	J 21
1974										
Adults ¹	2	3	2	2		2				
2-year-olds	0	0	1	0		0				
Yearlings	0	1	0	0		0				
Total	2	4	3	2		2				
1975										
Adults ¹	2	2	2		3	2	3	2		
2-year-olds	0	1	0		0	0	0	0		
Yearlings	1	2	0		1	0	2	2		
Total	3	5	2		4	2	5	4		
1976										
Adults ¹	3	2	2		2	3		3	3	2
2-year-olds	0	2	0		0	0		1	0	1
Yearlings	1	1	1		0	2		0	0	1
Total	4	5	3		2	5		4	3	4

¹ Adults were all birds 3 years old or older (see Hardy 1973).

parental group for at least several months after fledging. Study of groups with individually marked birds indicated considerable stability in group membership and home range from season to season and also from year to year. There was some evidence of interchange of members between groups and of the dissolution of groups. Changes in numbers of breeding groups from year to year (Table 2) partly reflect this instability but also reflect variations in scope and intensity of our field effort.

Movements, home range, territory.—Data on the size of home ranges were derived from watching birds, especially of group B. The area outlined in Fig. 1 is close to 25 ha. In 1976 group B shifted its home range somewhat to the NW and enlarged it to perhaps 30 ha. Sightings of known individuals of other groups were too few to attempt similar estimates. If it is assumed that locations of nests reflect distributions of home ranges and that distances between nests reflect sizes of home ranges, then the mean distance between nests of adjacent groups might be a reasonable estimate of the mean diameter of the home ranges. This mean inter-nest distance in 1974 was 558 m

($N = 5$), giving an areal estimate of 24 ha; in 1975 the nests were more dispersed and the comparable figures are 660 m ($N = 6$) and 34 ha; comparable figures for 1976 were 540 m ($N = 6$) and 25 ha. A third approach is to divide the total study area—i.e., that total area used by the known groups—by the number of groups. In 1974 6 groups occupied about 110 ha, for a mean area of 18 ha; in 1975 the 7 known groups occupied about 300 ha for a mean of 43 ha; in 1976 the 8 groups in a similar area averaged 38 ha per group. Considering the large size of the study area and the difficulty of observing the birds, the degree of agreement among these estimates is satisfactory.

The question of whether the home ranges are territories, defended against members of neighboring flocks, is of some importance. The use above of inter-nest distances and mean of total area occupied to estimate home range sizes assumes that groups occupy exclusive home ranges. If that assumption were true then the likelihood of territoriality would be high. All of our observations of marked birds suggest that the home ranges were exclusive or nearly so. Furthermore, the agreement between the estimate from sightings of the home range of group B and the estimates derived under the assumption of exclusive ranges is supportive. Finally, we have observed a number of instances of hostile interactions between birds of different groups that suggest territorial defense. Two of these were at the same site, 1 in winter and 1 in summer. This area is near the empirically determined boundary of group home ranges. Both involved aggression near an especially abundant food source, a pile of discarded tortillas in one case, a *Ficus* tree in heavy fruit in the other. In summary, the groups appeared to occupy home ranges of 20–40 ha, that were more or less exclusive to those of other flocks and were defended against members of the other groups.

Mobility within the home range was high. Individuals and groups seldom spent long periods at restricted sites (except the nest), moving from point to point freely, often in no discernible pattern. Often, flights of more than 100 m were made. Most of the time the birds kept to the forest. Special sources of food such as the mango orchards, railroad right-of-way, and highway shoulders where human garbage was dumped did attract birds from the forest, at times for protracted periods; otherwise they remained within it to forage, roost, rest, and nest.

NESTING

We did not study Beechey Jays in the prenesting period; in all 3 years nesting was well underway at the time of our arrival in early June, weeks before the end of the dry season. By back-dating, assuming an 18-day in-

cubation period and a 25-day nestling period, we deduce that laying was completed in early nests on the following dates: 19 and 27 May 1974, 2 on 22 May 1975, and 17 and 24 May 1976. Among Hardy's (1974) captive birds, courtship began in January and February and first attempts at nest-building occurred in April. The latest laying dates in Sinaloa, 9–11 July 1974, were in a known second nesting. In the captives molt became heavy in September and nesting activities ceased.

No exceptions were found to the rule that each group had only 1 active nest at 1 time. We know from direct observations that group B in 1974 and 1976 and group C in 1975 began second attempts after earlier ones had failed. For groups A, C, and D in 1974 we have indirect evidence that they made second attempts, for in spite of failure of their first attempts, they were accompanied in winter by birds of the year.

Nests were disorderly piles of dry sticks with a finer lining, resembling those of other species of *Cissilopha*. The mean height above ground of 15 nests was 5.5 m (range of 4.0–7.6). A large proportion were well concealed in the *Zizyphus* which is evergreen, or *Trichilia trifolia* many of which retain their dead leaves throughout the dry season.

Our data on clutch-size are fragmentary because in over half the nests hatching had already occurred before they were discovered and in many of the others incubation was well advanced. Of nests with incubation in progress, 5 contained 5 eggs when discovered, 1 contained 4 eggs, and 4 contained 3 eggs. It is possible that some of the nests had suffered losses of 1 or more eggs prior to discovery. In the single nest at which we were able closely to follow laying, the clutch was 3 eggs.

ATTENTIVE BEHAVIOR AND COOPERATION

Observations of activities at nests in all 3 years provide data to document and describe the form and degree of cooperation of group members in attending nests; and the following discussion will stress that cooperation, giving little emphasis to other aspects of attentive behavior.

Nestbuilding, incubation, brooding.—Data on nestbuilding were derived from observation of the activities of group B, which was discovered to be in the late stages of constructing nest 3B on 4 July 1974. All of the birds were marked prior to that date, but heavy foliage made observation difficult, and birds were not identified on many visits. All 4 of them visited the nest during construction. At least 3 of them worked at shaping the nest from a sitting position in the nest, but the adult female (PP) did most of this, particularly in the final stages. More than 1, and probably all, brought nesting material.

Nearly all of our data on incubation was obtained at nests 2 and 8B, each attended by an unaided pair. Apparently all of the incubation was done in each case by 1 bird, judged by the presence of an incubation patch to be a female. At both nests the male (the same individual, OO, in the 2 different years) fed the incubating jay at irregular and infrequent intervals. On about half of the occasions when the female left the nest, the male "guarded" the nest from the rim or nearby for a portion of her absence.

Brooding, which was frequent early in the nestling period and ceased on about the tenth day, was likewise performed by a single individual, the nucleus female in all instances when the identity of the brooder was known. As with incubation, on some occasions when the brooder left the nest another member remained to watch the nest.

Feeding of nestlings and fledglings.—For all 10 nests at which feeding of nestlings was observed for more than brief periods, all members of the respective groups participated in the feeding. At 3 others observed briefly, all either fed nestlings or mobbed observers. Because of the high percentage of marked birds the data on the division of labor within group B in 1974 and 1975 are the most detailed for any of the larger groups; they are presented in Table 3. Obviously all members contributed significantly, though contributions were not equal. In both nestings the female parent PP contributed less than others.

Groups at nests 9 and 10 exemplify the division of labor at nests with fewer attendants. The members of the unaided pair at nest 9 brought food the same number of times (21 vs. 22). At nest 10, where a yearling aided a nucleus pair, the 77 observed feedings were approximately equally divided among the 3 attendants.

Food brought to a nest with nestlings being brooded or with another bird guarding it was on some occasions passed to the attending bird. Usually on such occasions both birds then fed the nestlings.

With variation from 2 to 6 in the number of individuals bringing food for nestlings, there was possible variation in feeding rates correlated with the number of feeders. Comparable data are few and conclusions are ambiguous. Nests 7 and 10 were comparable in timing and each contained 3 nestlings, but nest 7 had 5 attendants while nest 10 had 3. For comparable periods we recorded 50 feeding visits in 10.7 h of observation at nest 7, for 4.7 visits/h, and 64 feedings in 14.7 h, 4.3/h at nest 10. The difference between these rates is negligible. On the other hand, in a similar comparison between nest 7 and nest 9, which was attended by only a pair, the rates were 4.5 and 3.2, respectively.

On 30 June 1974 the single youngster in nest 6 fledged. For the next 2 days this fledgling was sufficiently sedentary to allow prolonged observations

TABLE 3

PERCENTAGES OF FEEDINGS OF NESTLING BEECHEY JAYS BY DIFFERENT MEMBERS OF GROUP B AT NEST 3A (1974) AND NEST 7 (1975)

Nest 3A (74 feedings)	Individual:	PP, nucleus female	WV, nucleus male	AA, adult female	GG, yearling	
		11	36	16	36	
Nest 7 (89 feedings)	Individual:	PP	WV	GG	OG, yearling	PV, yearling
		18	26	21	10	25

of its activity and that of its attendants, an unaided pair. In a combined period of 4.8 h it was fed 26 times, a rate of 5.4/h, which is higher than we have observed for nestlings. One or the other parent was frequently nearby, but they seemed not to make a special effort to accompany the juvenile. The male attendant made over twice as many of the feedings as the female. In addition to the visits when food was actually delivered to the youngster, there were 10 visits in which parents attempted to feed, but left when the youngster refused to open its mouth. By the second day out of the nest the fledgling had become quite mobile, and by the third day attempts to find it were unsuccessful even though it was still alive, as we discovered the following January.

FOOD AND FORAGING

Analysis of stomach contents gave the following results: mammals (1 possibly *Reithrodontomys*) in 2 of 11 stomachs; lizards (*Anolis* and other, unidentified) in 2; Coleoptera (including at least Curculionidae and Cerambycidae) in 9; Lepidoptera (larval Geometridae) in 2; Orthoptera and spiders in 1 each; snails in 3; and seeds (corn, oats, and other, smaller ones) in 8 of 11. Observations of birds foraging or carrying food extend the variety. They include 5 instances of capture of lizards, including the common *Anolis*, and 3 additional ones of delivery of lizards to nestlings. Invertebrates captured or delivered include mosquitoes, winged termites and ants, cockroaches, cicadas, adult Lepidoptera of several kinds, many unidentified insects, and, especially, geometrid larvae, of which there was an outbreak of large numbers for about a week soon after the onset of rains each year. Vegetable material seen eaten includes waste grain along the railroad, corn on the ground or on stalks in cornfields, mangos from both trees and ground in orchards, immature fruit at the bases of flowers of

Ceiba trees, wild figs, a variety of berries from trees and shrubs, and tortillas from trash dumps.

Sites and modes of foraging also were varied. Foraging occurred within the forest and at its edges, in cornfields, mango orchards, and along the railroad right-of-way. Approximately equal numbers of our observations of foraging were of birds on the ground and in trees, with a lesser number in shrubs. Individuals foraged in all portions and levels in trees. They picked lizards, invertebrates, and fruit from foliage and branches; probed in cracks, under loose bark, into epiphytic bromeliads, into leaf litter on the forest floor; and even hawked after flying termites.

DISCUSSION

The findings presented in this paper have some significance in our overall comparative study of the sociobiology of the several forms of *Cissilopha*. Table 4 summarizes the salient features of *C. beecheii* that are shared with the other forms and the important differences. Data for the comparison are from Hardy (1973, 1976), Raitt and Hardy (1976), and a concurrent study of *C. s. sanblasiana*. Comparative characteristics of other forms stress those of *C. yucatanica* and *C. s. sanblasiana*—especially where there is variation apart from that involving *beecheii*—because we know more about the ecology of their social systems than those of *C. melanocyanea* and *C. sanblasiana nelsoni*.

Similarities between *beecheii* and the other forms are numerous and include important features of their ecology and breeding biology. They support the usual conclusion based on morphology and other taxonomic characters that *beecheii* is closely related to the others, and indicate that it occupies a generally similar niche. The differences are more interesting, for they are more numerous and more striking than the differences among the other forms. Of these differences it is highly likely that the lower degree of sociality, the fewer nests per group, and the low density are interrelated and are adaptive responses to a harsher environment than that occupied by the other forms of *Cissilopha*. As pointed out earlier, the climate in which the Beechey Jay lives is more xeric than is the range of the Yucatan Jay, and perhaps more importantly, it is characterized by a longer, more severe dry season, averaging over 6 months. Differences in the vegetation and well known regional variations in climate indicate that the ranges of the San Blas and Bushy-crested jays are likewise less xeric and less seasonal than that of the Beechey Jay. We postulate that the climatic regime of the latter results in generally lower and highly seasonal productivity of food resources, which would thus simply not support the

TABLE 4

SUMMARY OF SOME SIMILARITIES AND DIFFERENCES BETWEEN *C. BEECHEII*
AND OTHER FORMS OF *CISSILOPHA*

Feature	Comments
Similarities	
age differences in phenotype	—3 recognizable classes in fully grown birds
breeding season	—begins in dry season (May), extends into wet season (July–August)
nests (see also below)	—structure, placement similar in all forms
eggs	—shape, size, color similar in all forms
incubation, brooding	—1 bird does all or nearly all, except often 2 in <i>melanocyanea</i> and <i>sanblasiana nelsoni</i>
spatial structure	—groups with stable, probably exclusive, ranges
cooperation	—(a) group helps during nest construction
(see also below)	—(b) incubator-brooder attended, nest guarded (extent variable)
	—(c) all members of group feed nestlings and fledglings(?)
Differences	
body size	— <i>beecheii</i> larger: mean body wt. = 195 g; <i>yucatanica</i> : 122 g; <i>s. sanblasiana</i> : 111 g
breeding season groups	—smaller: 2–5; average about 12 in others and none normally as few as 3
cooperation	—greater division of labor in some forms
nests	—no overlap in attempts in <i>beecheii</i> but always in others; 2 or more potentially successful in others, only 1 in <i>beecheii</i>
density (biomass)	—low: ca. 10/km ² (1.95 kg/km ²) in <i>beecheii</i> ; ca. 70/km ² (8.54 kg/km ²) in <i>yucatanica</i> ; ca. 170/km ² (18.87 kg/km ²) in <i>s. sanblasiana</i>
diet	—varied, omnivorous in all; vertebrates more common in <i>beecheii</i>
habitat	— <i>beecheii</i> more dependent on forest; others prefer edge or open forest or plantations; <i>beecheii</i> habitat more xeric

locally heavy trophic demands of the large social concentrations and multiple nests characteristic of the other forms.

The causal relationships involving large body size are less clear. Large body size makes high sociality less likely, in terms of the ability of the food supply of a given area to support a given biomass. But large size may itself be an adaptation to a reduced food supply. Large size may seem to be a specialization within *Cissilopha*, but it may in fact permit a more generalized diet. Schoener (1971) points out that "unless food supply is very abundant, larger animals should . . . usually eat a greater range of food sizes than smaller ones," and Wilson (1975) has recently presented data for several groups of birds which confirm the fact that larger species eat a broader size range of food items. Such seems to be the case with *C. beecheii*: its diet includes the same sizes of seeds and arthropods as that of *C. yucatanica* but it also eats a substantial number of vertebrates, which the smaller jays would have more difficulty in capturing and handling. The postulated adaptive advantage of the more generalized diet in an area of seasonally low food supply is that the vertebrate prey may be a resource to be relied upon when food is scarce and needs are great, whereas smaller food items and fruits, supplies of which are characteristically highly abundant but temporary, may be capitalized upon at other times. Because these other food items are often locally abundant—e.g., termite and ant swarms and fig-laden trees—it is feasible in the sense of time-energy budgets for the larger jays to include them in their diet even though individual items may be small. It is also possible that body size is related to inter-specific selection pressures (Schoener 1971, Cody 1974), but this is an unlikely explanation for the larger size of Beechey Jays because their most likely competitors, the Mexican Crow (*Corvus imparatus*) and Magpie Jay (*Cyanocorax formosa*), are both at least as large as they are. Diffuse competition remains an elusive possibility.

Two additional important questions arise as a result of the previous discussion: (1) In view of the above arguments concerning low sociality in Beechey Jays, what is the advantage of the existence of the larger groups with a degree of social cooperation? and (2) In a proximate sense, how are the groups kept small, in the face of apparently strong social tendencies? The first of these questions is a portion of one of our primary questions in originally undertaking comparative study of this group of jays; it can be better approached in the context of the 4 species, with data from additional field study, especially concerning reproductive success of pairs vs. larger groups. As for question 2, Hardy (1974) presented evidence from study of a few captive birds that, in confined situations of cage or aviary, an adult male of a mated pair was strongly intolerant of another adult male. When

the latter was placed in a cage with the pair, it was severely pecked and would have been killed had it not been removed. So long as it was in sight of the male, however, that individual remained in an aggressive state, directing threat postures and pecking toward the other male. As mentioned previously, yearlings predominate as helpers, and never more than 1 adult has yet been recorded as a helper in one of our groups. Thus the groups may be kept small by the intolerance of the nucleus male toward other adults. As yet, we do not know the sex of these adult helpers. It is possible that group size may be limited without social interactions, through a balance of reproduction and death. Such limitation would appear to require independent density-dependent effects on each group, perhaps a less likely possibility than the operation of social exclusion of the sort observed in captive birds.

CONSERVATION STATUS

The Beechey Jay is a distinctive Mexican endemic with a restricted geographic range. It occupies a habitat the existence of which is precarious in the face of growing human population and agricultural development. In a major portion of its range, north of Culiacán, Sinaloa, into southern Sonora except along certain rivers, the deciduous forest has been virtually replaced by pasture and cropland. Our experience in the last decade is that clearcutting of the Beechey Jay's woodland habitat is accelerating. Earlier, when simple handheld tools were used merely to prune out small tree trunks, the woodland still maintained its basic character. Our entire study area is clearly second growth and seemingly when in this form remains good habitat for the jay. We have seldom, however, observed the jay where the forest has been severely changed in structure or removed. Although Beechey Jays may forage briefly in open areas adjacent to forest, unlike their close relatives they prefer more than forest edge, always retiring to the interior for most of their activities, including nesting. Consequently, we judge the Beechey Jay to be threatened and perhaps endangered by standards currently applied by governments and conservation agencies. The jay's extinction seems possible within the next few decades if habitat destruction continues at its present pace.

SUMMARY

We studied the Beechey Jay most of 3 breeding seasons and in 2 short non-breeding periods near Mazatlán, Sinaloa, México. We color-marked 28 fully grown birds and 33 young. The Beechey Jay lives in low deciduous forest, mostly second growth, on the coastal plain and low rolling hills of western México from Sonora to Nayarit. Near Mazatlán, the dry season usually extends from November into June.

The jays live year round in social groups of 2-5 individuals ($\bar{x} = 3.4$). The basic unit seems to be an adult male-female pair; birds accompanying the pair range from yearlings to adults, but yearlings predominate. Groups are relatively stable, but some shifts occur in membership from year to year.

Group home ranges were 24 to 43 ha and seemed virtually exclusive, suggesting territoriality, as did hostile interactions between birds of different groups near the empirically determined home range boundaries. Mobility within the range was high, and birds could be seen regularly only near nests. Beechey Jays are largely birds of the forest interior, venturing to the edge or the open only briefly to forage, usually in early morning or late evening.

Groups had no more than 1 successful nest per year; an early unsuccessful attempt was soon followed by a second attempt. Nesting began in the dry season in early May (completed clutches known from 17 and 19 May). Latest laying dates were 9-11 July, presumably in second nestings. Nests were disorderly piles of sticks with a finer twig lining, placed an average of 5.5 m up, usually in trees that had retained some foliage, such as *Zizyphus* and *Trichilia*. All group members helped in nest building, with the adult female of the nucleus pair doing most of the construction. Incubation and brooding were solely by this female, who was attended mostly by her mate. When the female was off the nest another bird usually remained as a "guard" nearby or on the rim of the nest. Five eggs were the most common clutch-size; smaller clutches may have resulted from predation.

All group members fed the young, all contributing significantly. Between 4 and 5 feeding visits to the nest/h was typical for groups with helpers; at 1 nest where only a pair attended the young the average was 3.5 visits/h. A single fledgling was fed 5.4 times/h, though there were other visits when the young would not accept food. By the second day out of the nest a fledgling was quite mobile. Though still alive, it was not locatable on the third day.

Beechey Jays have an extremely varied diet including small seeds, fruits, insects, lizards, and mice. Sites and modes of feeding were varied; besides the forest, from ground to canopy, jays took food on a railroad right-of-way and in orchards. They probed bark, gleaned foliage, searched leaf litter, and hawked insects.

Similarities in morphology and behavior indicate a close relationship between the Beechey Jay and other black-and-blue Jays. However, the ways in which it differs are interesting. It seems to be a form whose differences represent responses to a more arid, more highly seasonal environment. The lower degree of sociality, fewer nests per group, and low density are apparent responses to reduced and/or less predictable food supply in a less productive habitat. Large size may be related to this pattern, being itself an adaptation to reduced food resources. Recently certain authors have postulated that among related bird species, larger ones eat a broader size range of items. Small group size may be the result of intolerance of the nucleus male to other adults (males only?) but field evidence is lacking.

The Beechey Jay should be regarded as threatened or endangered, since it requires forest and its habitat is being clearcut and put to grazing and agricultural use, as well as encroached on by human populations.

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